DESIGN AN APPLICATION COMPATIBLE WITH HF RADIOS FOR MESSAGING AND DATA SHARING

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In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report

"Design an Application Compatible with HF Radios for Messaging and Data Sharing"

is carried out by

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DECLARATION OF ORIGINALITY

We hereby declare that no portion of the work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

ACKNOWLEDGMENTS

Allah Subhan'Wa'Tala is the sole guidance in all domains.

Our parents, colleagues, and most of all supervisor, **Maj Muhammad Junaid Khan**, and co-supervisor **Maj Muhammad Qasim(R&D)** without your guidance.

The group members, who through all adversities worked steadfastly.

Plagiarism Certificate (Turnitin Report)

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ABSTRACT

HF radios can be used to establish long-range communication, making them useful for emergency response, disaster relief, and military operations, where reliable communication is crucial for safety and coordination. In remote areas or situations where infrastructure is damaged, HF messaging applications can provide a means of communication when other forms of communication are unavailable. Additionally, HF messaging applications can provide a secure means of communication that is not reliant on third-party services, making them a viable option for sensitive communications in high-security environments.

The goal of our project is to design an application that is capable of sending messaging on HF Radios being used by the military, which can provide data sharing over the voice channel, which can be more efficient in terms of speed of delivery in the battlefield. Our project is indigenously developed and its integration with HF radios is done on known procedures: which are not known in the existing application held by Pak Army. We also help to provide affordable hardware for integrating the application with military-grade HF Radios.

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Chapter 1: Introduction

Professional skills based on scientific experimental knowledge and the science of numbers fashion a new branch of science known as Engineering. This branch of science is extremely important to society and its elements in many ways, especially the developmental research in the engineering domain that is boosting the standard of living for mankind.

Engineering is not only limited to the smaller research areas, but it covers entire industrial setups from visual constructions on some software to on-site practical work. Not only this, but this field of science also defines safety policies and evaluation measures. Engineers, who are practicing engineering principles, use their domain knowledge to invent and develop products that solve problems of the society. Whether it is an issue of conveyance, medicine, astrology, atmosphere, or entertainment.

With the advancement in engineering knowledge, automation has found a respectful place in the present research interests. Automation is a product of engineering research. It is the process in which machines are learned according to the existing events and are programmed in a way to make decisions in the future either by prediction or by previous trends. Formerly, mechanization is generally considered as a human labor replacement by machines. Whereas automation is a general integration of machines into a self-governed system.

Automation has completely revolutionized research interests. Where it has been introduced, it has completely changed the on-ground realities. It is no shame to say that it has almost affected every domain of our lives.

The present-day problems demand automatic solutions that are efficient. Traffic administration problems such as traffic congestion should also be dealt with solutions based on the latest technology.

1.1 Overview

Today's world is a world of digitization. The growing tech field and exponential development in the fields of transport, medicine, and metropolitan cities have become the most influential developments in the lives of mankind. The ability to share information in real time is essential for military operations. However, traditional communication methods such as radio transmissions often suffer from limited bandwidth, interference, and other technical challenges that can affect the reliability and effectiveness of communication. To address these issues, we propose the design of a messaging application that is compatible with HF radios for data sharing in the military. Our goal is to leverage the capabilities of the Fldigi application and integrate it with the Harris 5800 HF radios to enable reliable and efficient data transmission. The messaging application will allow military personnel to transmit data such as text over HF radio channels, thereby overcoming the limitations of traditional communication methods. This project aims to contribute to the development of a more reliable and effective communication infrastructure for military operations and has the potential to significantly improve the safety and efficiency of military personnel in the field. In this thesis, we will describe the design and implementation of the messaging application, as well as the results of our experiments and evaluations.

1.2 Problem Statement

Communication is a critical component for the safety and success of military operations. High Frequency (HF) radios are commonly used where other forms of communication are unavailable. However, sharing data through HF radios can be challenging due to limitations in bandwidth and data transfer rates. The existing messaging applications are often incompatible with HF radios, leading to difficulties in data sharing and slow data rates. Therefore, the specific problem this project aims to address is to integrate an open-source application (**fldigi**) with Harris 5800 HF radios to facilitate efficient data transfer in remote military environments. This will enhance communication capabilities and improve situational awareness, ultimately leading to better decision-making and mission success. The existing solutions (**Tactical Chat Software**) do not adequately address this problem due to the unique infrastructure of the application and proprietary communication protocols, which are unknown to us and pose security challenges in the military environment. This project aims to solve the problem by designing an interface between the Fldigi application and Harris 5800 HF radios to enable data sharing in real time.

1.3 Proposed Solution

The methodology for this project will involve researching the characteristics of HF radio communication and data transfer protocols, analyzing the compatibility of the **fldigi** application with Harris 5800 HF radios, designing and developing an interface between the two, and testing its reliability and efficiency in data transfer. It is important to note that this project does not aim to offer encryption for the instant messaging system. The successful completion of this project will contribute to enhancing the communication capabilities of troops in remote and austere environments, ultimately leading to improved situational awareness and mission success.

1.4 Working Principle

The project mainly works on the principles of digital modulation for converting textual data to tones that can be transmitted over the voice channel of HF radios. The project is divided into the following main parts:

- Designing the project.
- Convert text data into digital tones.
- Interface the modulated tones with Harris 5800 HF radio.
- GUI presentation.

1.4.1 Designing the Project

The integral part of the project is the design of our project. The project contains an open-source application (fldigi) obtained from https://sourceforge.net/projects/fldigi/ , an understanding of its communication protocols, and its integration/interfacing with military-grade HF radios.

1.4.2 Convert Text Data Into Digital Tones

Our application uses a modulation technique called "Audio Frequency-Shift Keying" (AFSK) to convert text into tones for transmission over a radio channel. AFSK is a type of digital modulation that shifts the frequency of an audio carrier signal based on the data being transmitted. In our application, this is done by generating an audio tone at a specific frequency for each bit of data. The tone frequency is shifted between two predefined frequencies, typically 1700 Hz and 2200 Hz, to represent a binary 1 or 0, respectively. Our application uses the computer's sound card to generate the audio tones, which are then sent to the radio transmitter. The transmitter converts the audio tones into radio waves and broadcasts them over the air. On the receiving end, the radio receiver detects the radio waves and converts them back into audio tones, which are then decoded by the application. The application can then use its decoding algorithms to interpret the audio tones and recover the original data.

1.4.3 Interface the Modulated Tones with Harris 5800 HF Radio

To interface the modulated tones created by our application with the Harris 5800 HF radio, we are using a combination of audio and serial RS232 connections*indigenous design of circuit*. The audio mic and speaker 3.5mm port of our computer is connected to the 6-pin PRC connector of our radio J3 port using an appropriate cable. We are also using a serial RS232 port to send a signal to a circuit containing an optocoupler, which activates the PTT (Push-to-Talk) of the radio. Once the PTT is activated, the modulated tones are transmitted over the radio channel using the radio's transmitter. On the receiving end, the radio's receiver is used to detect the transmitted signal, which is then demodulated back into the digital domain. The received audio signal is then decoded using our application to recover the original data. It is important to ensure that the audio levels are correctly set and that the audio signal is not distorted, and that the PTT circuit is properly designed and implemented to avoid any potential damage to the radio or other components.

1.4.4 GUI Presentation

The visual demonstration of the project is done through the aid of GUI (graphical user interface) which is already built-in into the fldigi application, we will modify the GUI for optimum utilization by our project.

1.5 Objectives

1.5.1 General Objectives

"To design an application for textual data sharing between military HF radios using Digital modulation techniques, providing a reliable and affordable alternative to proprietary and expensive chatting applications offered by radio companies."

1.5.2 Academic Objectives

- Conducting a literature review to identify relevant research and technologies in the field of HF communication and messaging applications.
- Applying theoretical and practical knowledge gained through coursework and training to design and implement a messaging application compatible with HF radios.
- Developing skills in software programming, hardware interfacing, and radio communication technologies.
- Presenting the project findings and results clearly and concisely, both in written form and oral presentations.
- Contributing to the field of military communication and technology through the development of a novel and practical messaging application.
- To increase productivity by working in a team.

1.6 Scope

The scope of our project is to design and develop a messaging application that is compatible with HF radios for data sharing in the military. We will integrate the Fldigi application with the Harris 5800 HF radios to enable efficient and reliable data transmission. Our software application will be capable of generating modulated tones from text, images, and files for transmission over HF radio channels. Additionally, we will design and implement a hardware interface that allows the modulated tones to be transmitted through the Harris 5800 HF radios. To evaluate the performance and effectiveness of the messaging application, we will conduct experiments and evaluations in a simulated military environment. We will document the design and implementation of the messaging application, including the software and hardware components, and the testing and evaluation results. Finally, we will identify potential improvements and future directions for the messaging application to enhance its functionality and usability in military operations.

1.7 Relevant Sustainable Development Goals

1.7.1 Primary SDG

- **SDG no 16** - Peace, Justice, and Strong Institutions

  This project helps in improving the security of the country. By improving the security situation in our country, we directly improve the law and order, and indirectly we improve peace, justice, and the standard of life of the population.

1.7.2 Secondary SDGs: Our project directly covers following SDGs:-

- **SDG no 8** - Decent Work and Eco Growth
- **SDG no 11** - Sustainable Cities and Community
- **SDG no 12** - Responsible consumption and production

1.8 Structure of Thesis

Chapter 2 contains the literature review this thesis is based upon.

Chapter 3 contains the operating modes, working & interfacing of application with Harris HF-5800 HF radio.

Chapter 4 includes the code and process of installation in the ubuntu platform.

Chapter 5 contains the conclusion of the project.

Chapter 6 highlights the future work that can add more features to the project.

Chapter 2: Literature Review

A new product is launched by modifying and enhancing the features of previously launched similar products. A literature review is an important step in the development of an idea for a new product. Likewise, for the development of a product, and its replacement, related to the traffic system, a detailed study regarding all similar projects is compulsory. Our research is divided into the following points:

- HF Radio Communication
- Fldigi Application
- PTT Control
- RS-232 Serial Port
- Optocoupler
- PRC 6-pin connector
- Software Modification

2.1 HF Radio Communication

HF radio communication is a type of wireless communication that uses high-frequency radio waves to transmit data over long distances using sky wave propagation (reflection from the ionosphere). It is commonly used in military and emergencies where traditional communication channels may not be available.

2.2 Fldigi Application

Fldigi is a free and open-source software application used for digital communications in amateur radio, marine radio, and other radio communication systems. It can be used for a variety of digital modes, including RTTY, PSK31, and JT65, among others.

2.2.1 RTTY, or Radio Teletype, is a method of transmitting text messages over radio waves using tones. It works by converting letters, numbers, and other characters into binary code, which is then transmitted as a series of tones.

2.2.2 PSK31, or Phase Shift Keying 31, is a type of digital modulation that allows users to send text messages and data over radio frequencies using very narrow bandwidths. It works by varying the phase of a carrier signal to represent the binary code of the message being transmitted.

2.2.3 JT65 is a digital mode of communication used for weak signal propagation. It is designed to allow users to communicate over long distances using low power levels and narrow bandwidths. It works by sending short bursts of data, which are decoded by the receiving station and used to reconstruct the original message.

2.3 PTT Control

PTT (Push-to-Talk) control is a mechanism used in two-way radio systems to switch the radio between transmit and receive modes. It is typically activated by pressing a button on the microphone or a separate PTT switch.

2.4 RS-232 Serial Port

RS-232 is a standard for serial communication transmission of data between computers and other devices. It is commonly used for communication between a computer and a modem, or in this case, between a computer and the PTT control circuit of Harris 5800 HF Radio.

2.5 Opto-Coupler

An optocoupler is an electronic component that transfers electrical signals between two isolated circuits by using light. It is commonly used in circuits that need to transfer signals between components that are not electrically connected. In this case, we trigger our PTT using an optocoupler in our circuit.

2.6 PRC 6-pin connector

The PRC 6-pin connector is commonly used in military radios and equipment. It has a rugged design and can withstand harsh environments. The pinout of the PRC 6-pin connector is as follows:

1. Audio output
2. Audio input
3. Ground
4. Push-to-talk (PTT) control
5. Not used
6. Not used

To interface the modulated tones created by our application with the PRC 6-pin connector, we needed to connect the audio mic and speaker ports on your computer to pins 1 and 2 of the connectors respectively. The PTT control signal is sent using the RS-232 serial port and the opto-coupler circuit as described earlier. It is important to note that any modifications to the hardware of our project were carefully considered and tested to ensure that they do not affect the functionality or safety of the system.

2.7 Software Modification

Software modification is the process of making changes to an existing software application to add new features or to modify its existing functionality. In this case, the modification to the fldigi application involves removing its unnecessary tabs from the GUI and adding useful options in the GUI.

Chapter 3: Operating Modes, Working & Interfacing of the Application with Harris HF-5800 HF Radio

3.1 OPERATION MODES

3.1.1 CW Mode

CW (Continuous Wave) mode is a simple and efficient digital mode used in Fldigi. It is used primarily for sending and receiving Morse code signals. In CW mode, Fldigi generates a continuous wave carrier signal at a specific frequency. This carrier signal is then turned on and off to create Morse code characters. The duration of the on and off periods determines the Morse code character that is being transmitted. To receive CW signals, Fldigi monitors the incoming signal and looks for changes in the carrier signals on and off periods. These changes are then translated into Morse code characters, which are displayed on the screen.

3.1.2 OFDM Mode

OFDM (Orthogonal Frequency Division Multiplexing) is a digital modulation technique that is used in many communication systems, including Fldigi. In Fldigi, OFDM is used in the PSK, QAM, and MFSK modes. OFDM works by dividing the data signal into multiple subcarriers, each carrying a portion of the total data. These subcarriers are orthogonal to each other, which means that they do not interfere with each other. By using multiple subcarriers, OFDM can achieve a high data rate while minimizing interference. In Fldigi, the OFDM mode works by generating a set of subcarriers that are spaced apart in frequency. The data is then modulated onto these subcarriers using a method such as PSK, QAM, or MFSK. The resulting signal is then transmitted over the communication channel. At the receiving end, the OFDM signal is demodulated by extracting the subcarriers and demodulating the data from each subcarrier. The demodulated data is then combined to reconstruct the original data signal. Overall, OFDM is an efficient and reliable digital modulation technique that is used in many communication systems, including Fldigi.

3.1.3 PSK, QPSK, 8PSK & PSKR Mode

PSK (Phase Shift Keying) is a popular digital modulation technique used in Fldigi. It is used to transmit digital information over a communication channel by modulating the phase of a carrier wave. QPSK (Quadrature Phase Shift Keying) is a type of PSK modulation that uses four phase states to encode two bits of information per symbol. 8PSK (8-Phase Phase Shift Keying) is a type of PSK modulation that uses eight phase states to encode three bits of information per symbol. PSKR (Phase Shift Keying with Reduced Alphabet) is a variant of PSK modulation that uses a reduced number of phase states to encode digital information. In Fldigi, PSK, QPSK, 8PSK, and PSKR modes work by modulating the phase of the carrier wave to encode digital information. The digital data is first converted into a series of symbols, and each symbol is mapped to a specific phase shift. The modulated signal is then transmitted over the communication channel. At the receiving end, Fldigi demodulates the PSK signal by detecting the phase shift of the received carrier wave. The phase shift is then used to decode the digital information that was encoded by the transmitting device. Overall, PSK, QPSK, 8PSK, and PSKR modes in Fldigi are effective digital modulation techniques that can be used to transmit digital data over a communication channel. These modes are popular in amateur radio and can be used for a wide range of applications, including voice and data communication, digital image transmission, and more.

3.1.4 Other Modes

Other op modes supported by Fldigi include, which will not be used for our communication purpose:

1. RTTY (Radio Teletype) - a mode used for transmitting text messages over radio channels.
2. MFSK (Multiple Frequency Shift Keying) - a mode that uses multiple audio frequencies to modulate digital information.
3. Hellschreiber - a mode that uses a type of facsimile technology to send images or text over a communication channel.
4. THOR - a mode that uses a powerful error-correcting code to ensure reliable data transmission over noisy channels.

5. Contestia - a mode designed for use in radio contesting, featuring a low data rate and robust error correction.
6. MT63 - a mode that uses a complex modulation scheme to achieve high data rates over a communication channel.
7. DominoEX - a mode that uses a waveform with multiple frequency shifts to achieve high data rates over a communication channel.

BPSK and QPSK	31, 63, 125, 250 (both), and 63F and 500 (BPSK only)
PSKR	125, 250, and 500
CW	speeds from 5 to 200 wpm
DominoEX	4, 5, 8, 11, 16 and 22; also with FEC
FSQ	
Hellschreiber	Feld Hell, Slow Hell, Hell x5/x9, FSKHell(-105) and Hell 80
IFKP	
MFSK	4, 8, 11, 16, 22, 31, 32 and 64; most with image support
MT63	500, 1000 and 2000
OLIVIA	various tones and bandwidths
RTTY	various baud rates, shifts, nbr. of data bits, etc.
THOR	4, 5, 8, 11, 16 and 22
Throb and ThrobX	1, 2, and 4
WWV	receive only - calibrate your sound card to WWV
Frequency Analysis	receive only - measure the frequency of a carrier

Figure 1 *Modes of Fldigi from Source-code*

Figure 2 *Modes in Menu*

3.2 USING & INTERFACING

3.2.1 Using the Application

Connect your computer to a radio transceiver or sound card interface. This will allow you to transmit and receive signals over the airwaves.

Connect your RS232 Port to a radio PTT circuit. This will allow you to control the PTT of the radio.

Launch the application and select the appropriate audio input and output devices in the "Audio" and "PTT control" tabs of the "Configure" menu.

Select the digital mode you wish to use for messaging from the "Op Mode" drop-down menu. For example, you can select PSK-31 for simple text messaging, or MFSK16 for more robust data transmission.

Start typing your message in the "Rx/Tx text" field. Your message will be displayed on the screen in real-time.

When you're ready to transmit your message, click the "SEND" button. The application will transmit your message over the airwaves using the selected digital mode.

Listen for incoming messages from other stations. Incoming messages will be displayed in the "Receiving msg from Radio" field.

Continue sending and receiving messages as desired. Remember to follow proper radio etiquette and regulations when communicating over the airwaves.

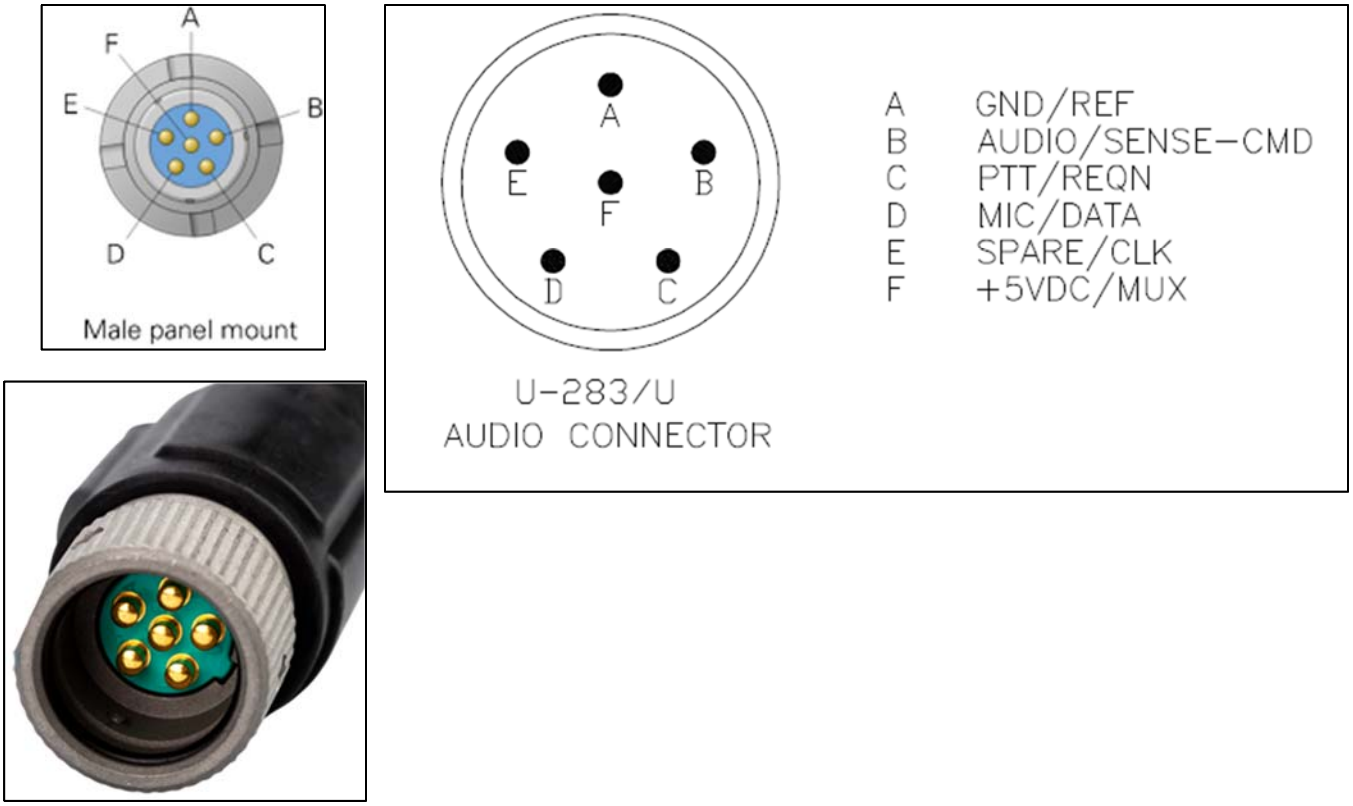

Figure 3 *J3 port of Harris radio / PRC 6 pin connector / pin diagram*

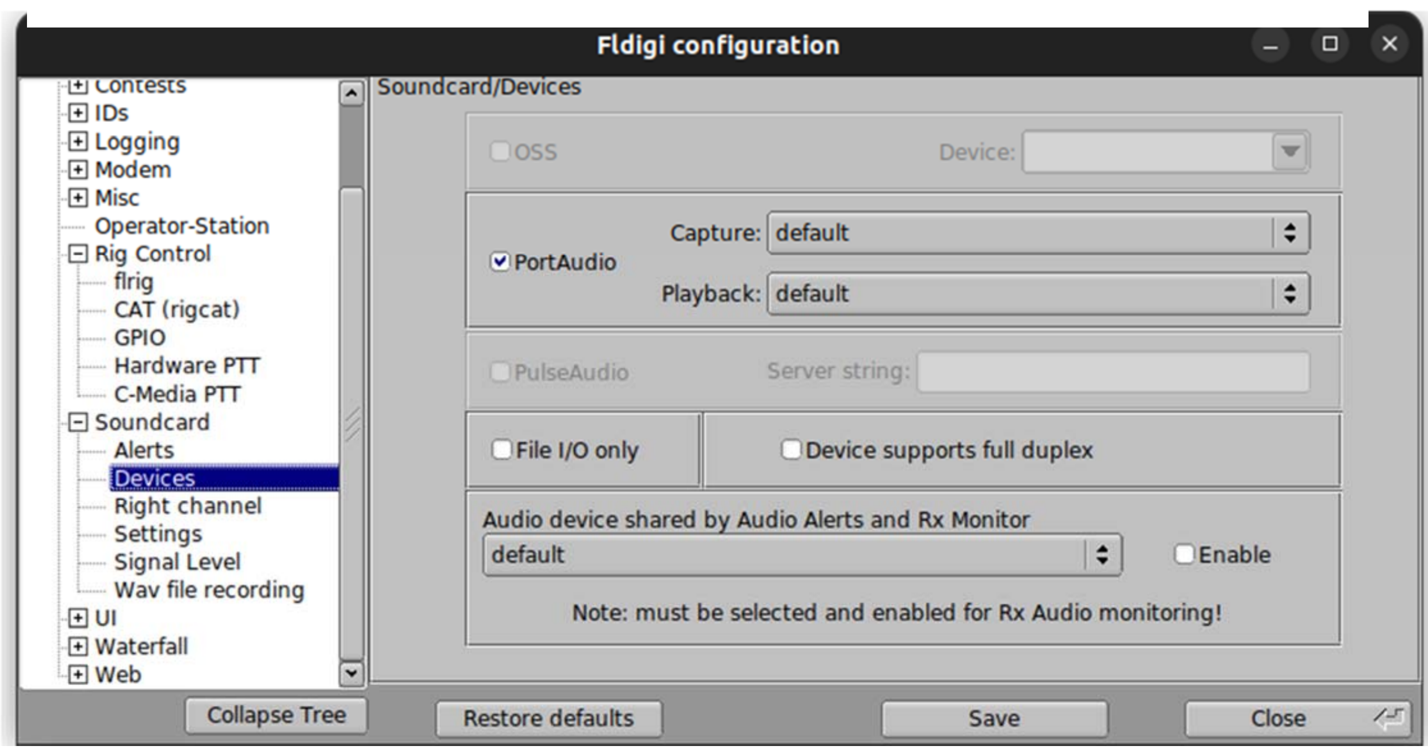

Figure 4 *Selection menu for Input/Output Audio Devices*

3.2.2 Interfacing the Radio & Application

To connect a Harris radio with a PRC 6-pin port to an RS232 port for PTT (push-to-talk) control, you will need to follow these steps:

1. Gather the necessary equipment. You will need an RS232 to TTL converter, a 9-pin serial cable, and a 6-pin data cable with the appropriate connectors for your Harris radio and PRC 6-pin port.
2. Connect the RS232 to TTL converter to your computer's RS232 port using the 9-pin serial cable. Make sure the converter is set to the correct voltage for your radio.
3. Connect the Harris radio's PTT output to the TTL converter's TXD input using the 6-pin data cable. The PTT output is usually labeled "PTT" or "TX."
4. Connect the TTL converter's RXD output to the Harris radio's RX input using the 6-pin data cable. The RX input is usually labeled "RX" or "AF."
5. Connect the TTL converter's GND output to the Harris radio's GND using the 6-pin data cable.
6. Connect the PRC 6-pin port to the TTL converter's RXD input, TXD output, and GND using the appropriate connectors on the 6-pin data cable.

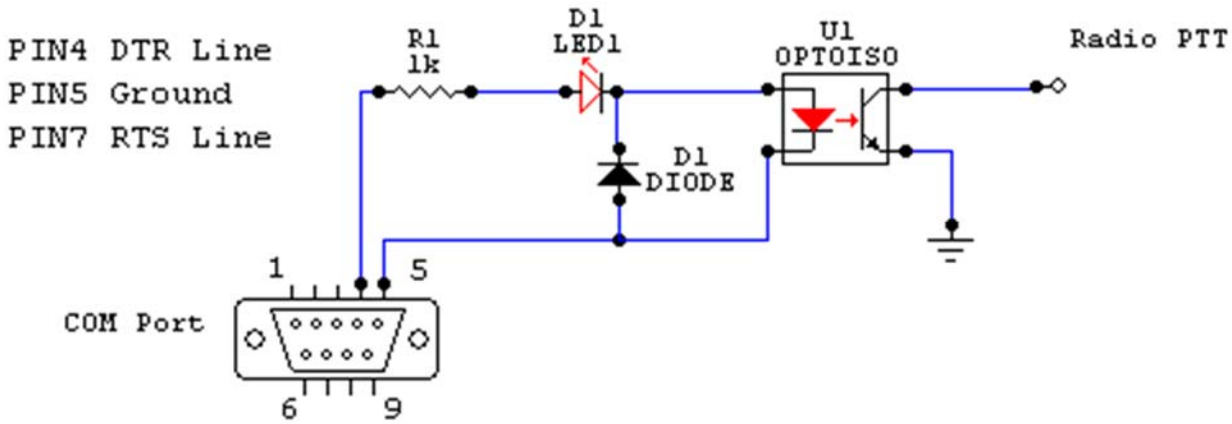

Figure 5 *Circuit Diagram of PTT control Circuit*

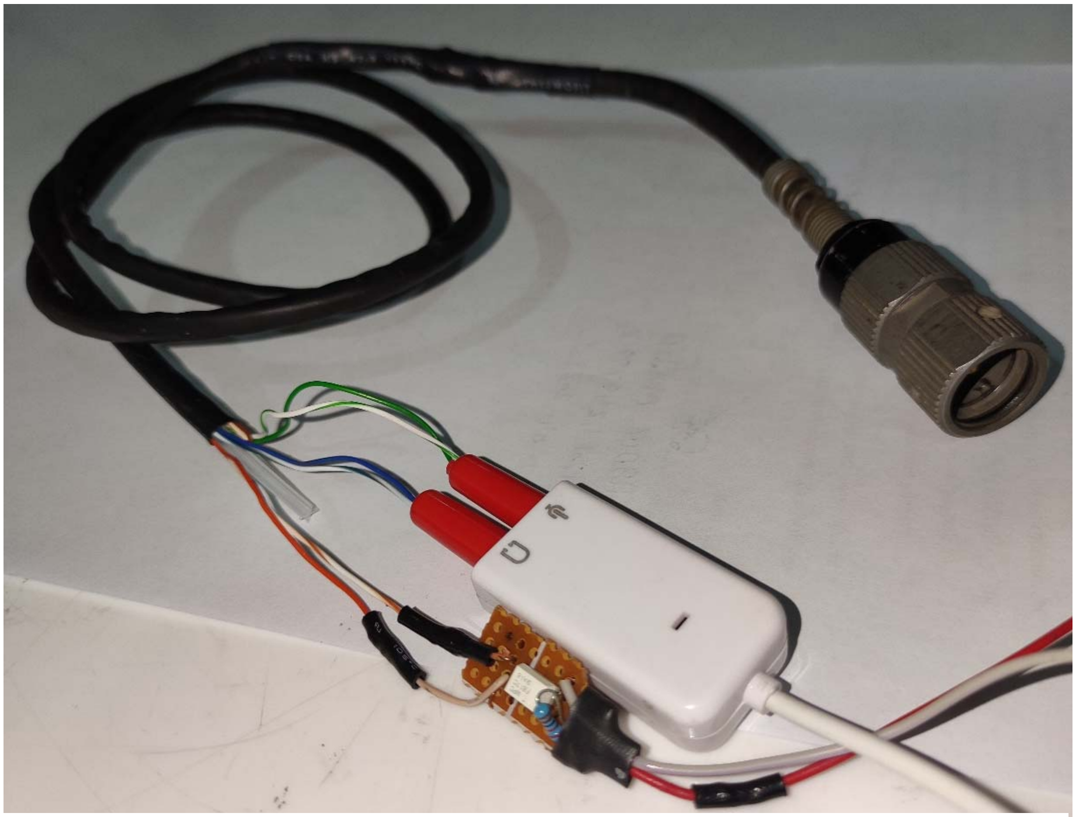

Figure 6 *Picture of the Indigenously Produced Cable*

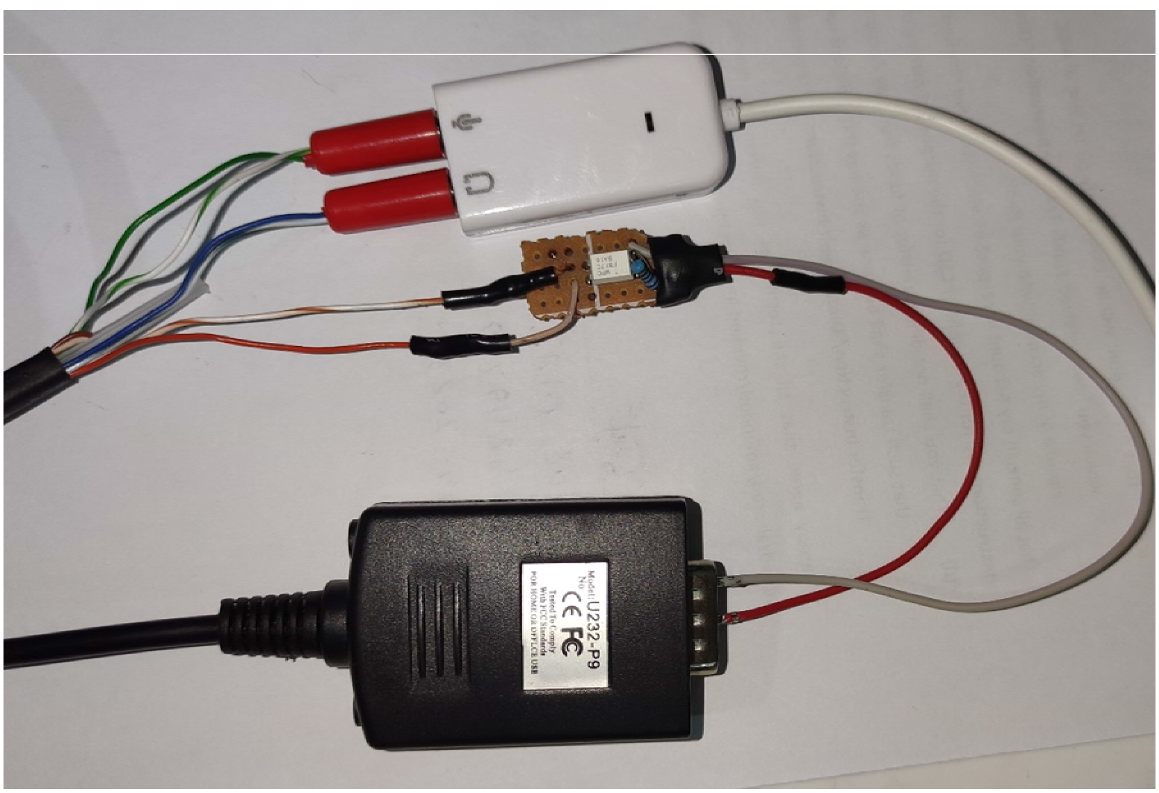

Figure 7 *Connection b/w RS-232 connector and PTT control circuit*

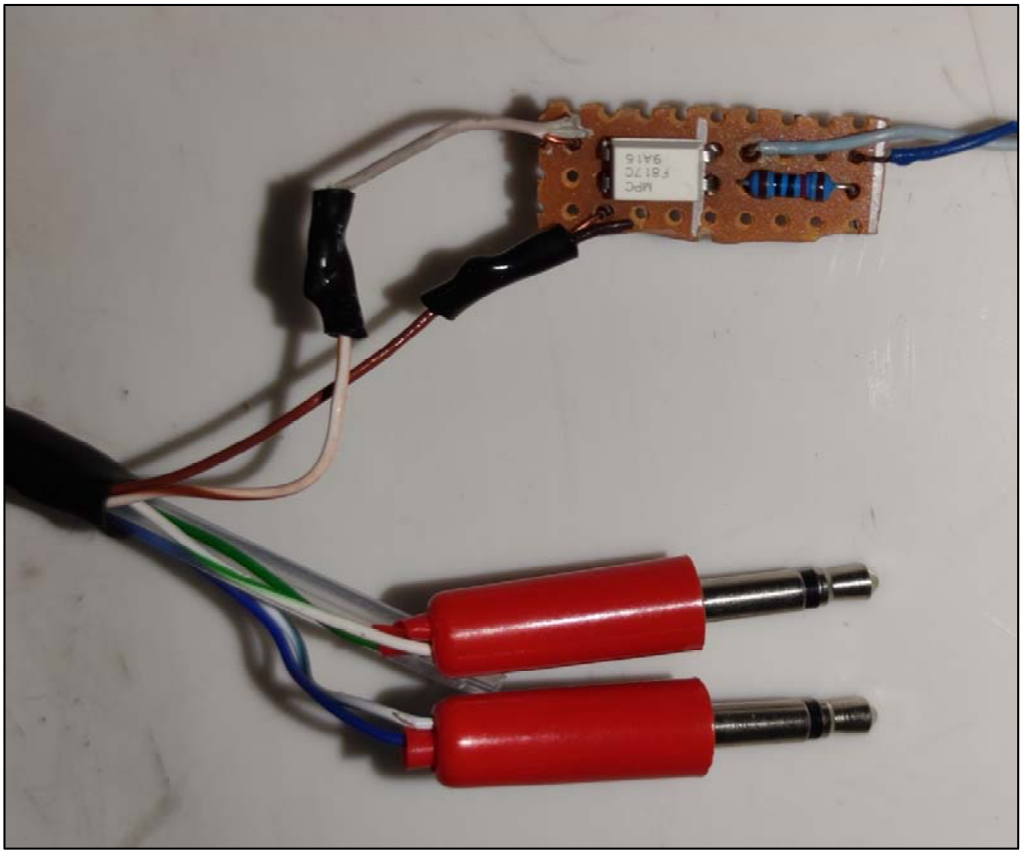

Figure 8 *3.5mm Audio cables from Radio PRC connector*

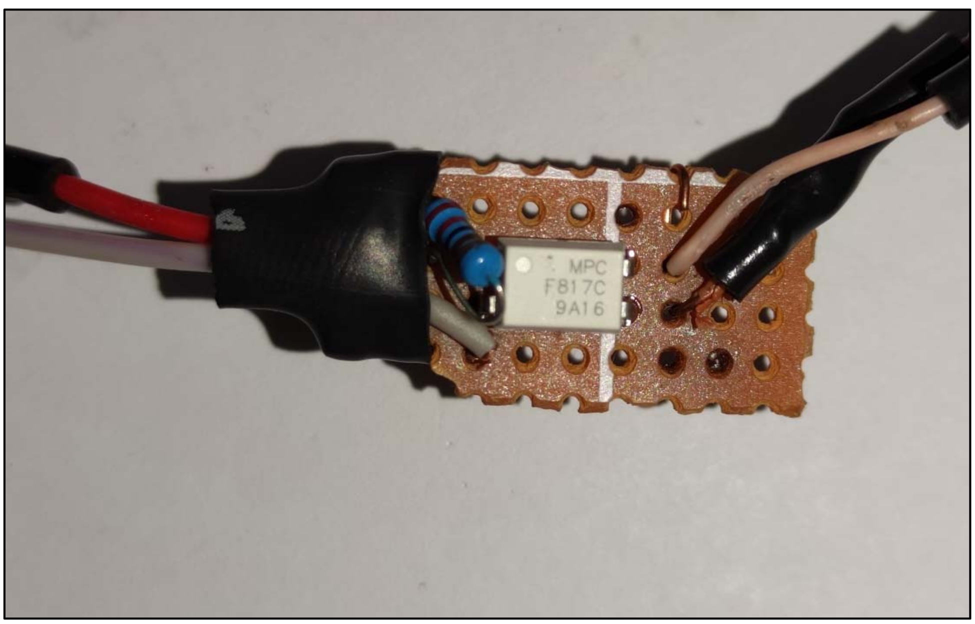

Figure 9 *PTT Control Circuit including Optocoupler (Physical)*

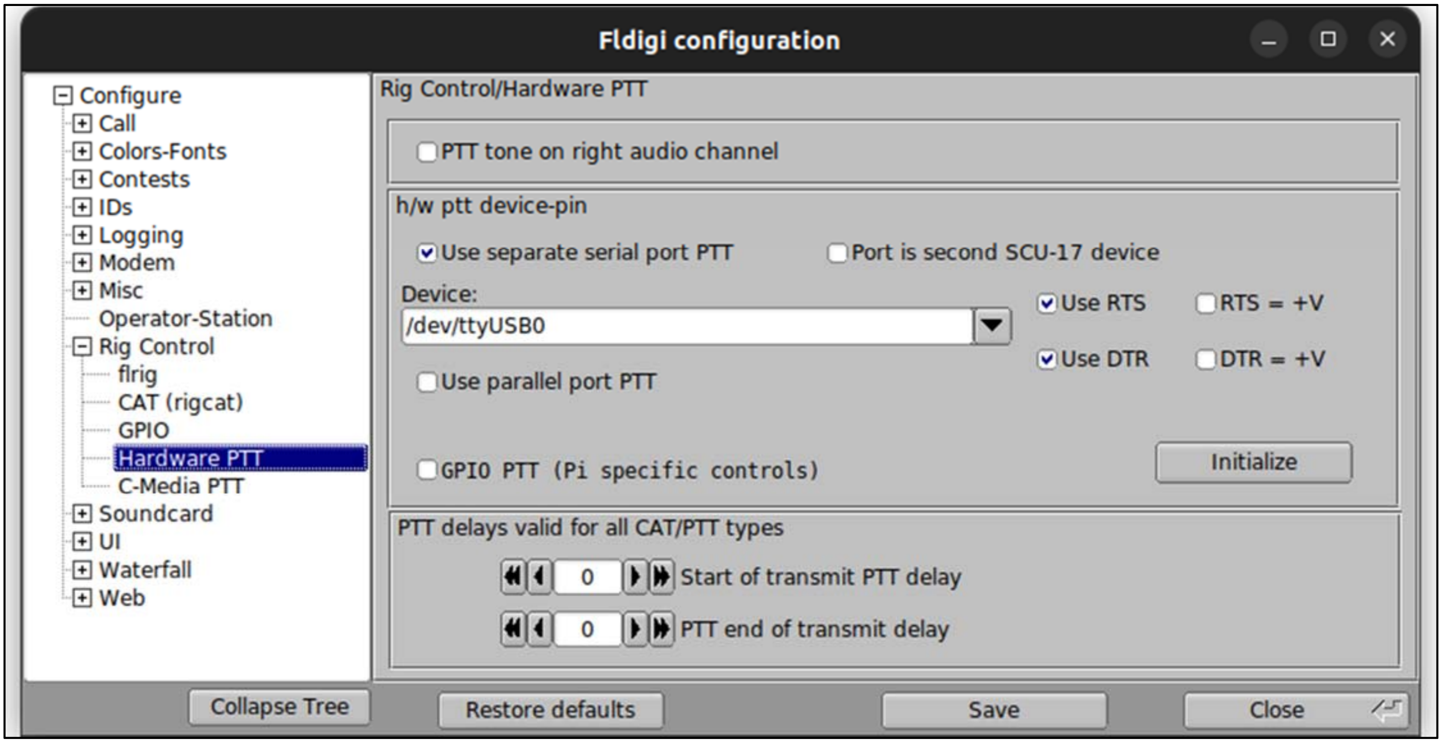

Figure 12 _PTT Control menu in Application_

Figure 10 _USB to RS232 serial cable_


Figure 11 _USB to 3.5mm Audio Jack_

CHAPTER 4: CODE / PROCESS OF INSTALLATION IN THE UBUNTU PLATFORM

DOWNLOAD LINK

http://ftp.debian.org/debian/pool/main/f/fldigi/

OR

http://ftp.debian.org/debian/pool/main/f/fldigi/fldigi_4.1.23.orig.tar.gz

EXTRACT THE DOWNLOADED SOURCE

tar -xzf fldigi_4.1.23.orig.tar.gz

cd fldigi-4.1.23/

COPY FOLLOWING FILE FOLDERS AND REPLACE IN *fldigi-4.1.23/src

1. /dialogs *2 x files a. fl_digi.cxx b. fl_digi_main.cxx
2. /misc *1 x file a. macros.cxx

BUILD DEPENDENCIES

sudo cp /etc/apt/sources.list /etc/apt/sources.list.bak

sudo nano /etc/apt/sources.list

deleting the leading " # " characters from the lines which start with " deb-src "

Save the changes with control-O

Exit //nano// with control-X

DOWNLOAD AND UPDATE APTITUDE PACKAGE

sudo apt-get install aptitude

sudo aptitude update

sudo aptitude install build-essential

sudo apt-get update

sudo aptitude build-dep fldigi

sudo apt-get build-dep fldigi

sudo aptitude install libxft-dev

sudo aptitude install libudev-dev

sudo apt-get install libfltk1.3-dev

sudo apt-get install -y samplerate-programs sudo apt-get install -y libsamplerate-dev

sudo apt-get install -y libsndfile-dev

sudo apt-get install libasound-dev

sudo apt-get install portaudio-dev

sudo apt-get install -y portaudio19-dev

sudo apt-get install gcc-9

sudo update-alternatives --config gcc

CHANGE SWAP SIZE *FOR LOW RAM PCS*

sudo swapoff -a

sudo chmod 600 /swapfile

sudo fallocate -l 2G /swapfile

sudo chmod 600 /swapfile

sudo mkswap /swapfile

sudo swapon /swapfile

CONFIGURE AND INSTALL

./configure --enable-optimizations=native

NOTE: If any dependency is missing during this process, install by using "sudo apt-get install mssing_dependency_name-dev "

make && sudo make install

INSTALL VOLUME CONTROL

sudo aptitude install pavucontrol

NOTE: run PulseAudio Volume control program and adjust volume at 50 percent on input and output

RUN

cd src/

./fldigi

USB SERIAL CONNECTION for WSL(linux)

1. INSTALL USBIPD FROM MSI FILE ON WINDOWS

https://github.com/dorssel/usbipd-win/releases/download/v2.4.1/usbipd-win_2.4.1.msi

2. SHOW USB DEVICES

usbipd wsl list

3. note busid of usb-serial device *1-1* and add to the following command

usbipd wsl attach --busid <busid>

SETTINGS ON UBUNTU OS

lsusb

this should show

Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub

Bus 001 Device 002: ID 1a86:7523 QinHeng Electronics HL-340 USB-Serial adapter

Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub

now usb serial device will be recognized as ttyUSB0

if not found, then use following:-

sudo modprobe usbserial vendor=0x4348 product=0x5523

And replace the 0x4348 and 0x5523 with vendor and product of your connector and it will be ready to be used from ttyUSB0 port from the application.

TO CHECK IF SERIAL IS CONNECTED

$ dmesg

AT THE END OF THE LINES YOU SHOULD SEE:

[1447.719428] usb 1-1: SetAddress Request (3) to port 0

[1447.760868] usb 1-1: New USB device found, idVendor=1a86, idProduct=7523, bcdDevice= 2.54 [1447.763905] usb 1-1: New USB device strings: Mfr=0, Product=2, SerialNumber=0 [1447.767340] usb 1-1: Product: USB2.0-Ser!

[1447.772267] ch341 1-1:1.0: ch341-uart converter detected

[1447.791795] ch341-uart ttyUSB0: break control not supported, using simulated break

[1447.793596] usb 1-1: ch341-uart converter now attached to ttyUSB0

Chapter 5: Conclusion

In conclusion, our project has achieved its primary objective of designing a messaging application that is compatible with HF radios for data sharing in the military. By modifying the open-source fldigi application and integrating it with the Harris 5800 HF radio using a serial RS232 port and opto-coupler, we have provided a simple yet effective way for soldiers to communicate vital data over long distances. Our project aimed to create an uncomplicated and secure method for military communication that does not require complex encryption methods. This successful implementation highlights the importance of digital modes of communication in military operations and demonstrates the potential of open-source software in developing specialized applications for specific use cases. We are proud to have contributed to the advancement of military communication technology through our project, and we believe that it will have a significant impact on the safety and success of military operations in the future.

Chapter 6: Future Work

While our project has achieved its primary objective of designing a messaging application compatible with HF radios for data sharing in the military, there is still ample opportunity for future work in this field. One potential area for improvement is the integration of more advanced encryption methods to enhance the security of the communication. Another possible future work is to explore the use of other digital modes of communication, such as Frequency Shift Keying (FSK) or Amplitude Modulation (AM), to determine their effectiveness and suitability for military operations. Additionally, the application could be further optimized for efficient use of resources and improved performance. In conclusion, there are several areas where future work could be done to build on the foundation that our project has laid, and we believe that continued research and development in this area will lead to significant advancements in military communication technology.

Some potential headings for the future work section could be:-

1. **Enhanced Encryption**: In this area of future work, more advanced encryption methods could be implemented to enhance the security of the communication between military personnel. This could involve the use of stronger encryption algorithms or the development of new encryption protocols tailored specifically for military applications.
2. **Exploration of Other Digital Modes of Communication**: While our project has focused on the use of RTTY, PSK31, and JT65 digital modes, there are several other digital modes that could be explored in future work. For example, FSK and AM could be investigated to determine their effectiveness and suitability for military operations. This could involve a thorough analysis of the advantages and disadvantages of each mode, as well as experimental testing to assess their performance in different environments.
3. **Optimization of Resources and Performance**: One potential area of future work is the optimization of the messaging application for efficient use of resources and improved performance. This could involve the development of new algorithms to improve data compression and reduce the amount of bandwidth required for communication. Additionally, the application's graphical user interface (GUI) could be optimized to improve usability and reduce the cognitive load on the user. Finally, the messaging application could be further tested and optimized for use in different operating environments, such as extreme weather conditions or low signal strength.

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